Linardakis, M., Papadaki, A., Smpokos, E., Kafatos, A., & Lionis, C. (2019). Prevalence of multiple behavioral risk factors for chronic diseases in medical students and associations with their academic performance. *European Journal of Public Health*. https://doi.org/10.1007/s10389-019-01030-2

Title: Prevalence of multiple behavioral risk factors for chronic diseases in medical students and associations with their academic performance

Running head: Behavioral risk factors and academic performance

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Abstract: 248/**250 words**

Text word count: 3,669/**--** (with the sections of Conflicts of interest statement etc)

References: 34/**--**

Acknowledgements

The authors would like to thank all students who participated in this study. We also thank to Mrs. Eleutheria Tzorakis, Olympia Ksilouris and Sofia Flouris for their valuable assistance in data preparation.

Funding

None declared

Disclosure of potential conflicts of interest

The authors declare that they have no conflict of interest

Abstract

Purpose Multiple behavioral risk factors (MBRFs) related to lifestyle have been associated with non-communicable diseases, but there is limited evidence on their prevalence in undergraduate medical students and their association with their academic performance.

Methods During 1989-2017, data from 1,447 medical students of University of Crete, Greece (mean age 21.8±2.2yrs), were analyzed. MBRFs assessed included smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits/vegetables. Academic performance was based on the grades received in the mandatory Clinical Nutrition course and the overall Medical degree (scale of 0-10).

Results From the sample, 25.8% were smokers, 30.7% had high body weight and 67.2% had low consumption of fruits/vegetables. Prevalence of having 'no MBRFs' and having 'multiple clustering' or '3+ factors' was 15.8% and 12.3%, respectively. Men had almost twice the prevalence of multiple clustering than women (16.5% vs. 8.4%, $p<0.001$). Participants who had none, compared to 3+, MBRFs had higher mean grades in the Clinical Nutrition course (6.34 vs. 5.94, $p=0.027$, p-trend=0.003) and overall degree (7.39 vs. 7.22, $p=0.021$, p-trend=0.002). As the number of MBRFs increased (from 'none' to '1', '2' and '3+' factors), the proportion of graduates receiving a distinction also decreased (6.1%, 3.3%, 3.3% and 0.0%, respectively, p-trend=0.001).

Conclusion Overall, high prevalence of MBRFs was observed in this sample of medical students, while MBRF clustering was prospectively inversely associated with academic performance. These findings highlight the need for preventive lifestyle strategies to improve these students' behavioral risk factors and academic performance during their studies.

Keywords: behavioral risk factors; chronic diseases; medical students; academic performance; grades; bachelor.

Introduction

Lifestyle habits or multiple behavioral risk factors (MBRFs) involve unhealthy and risky behaviors which have been associated with increased morbidity and mortality from a variety of preventable chronic diseases (Fine et al. 2004; WHO 2014). These factors often refer to smoking, high body weight, unhealthy dietary choices, such as low consumption of fruits/vegetables and high consumption of red meat, physical inactivity and/or sedentary behavior, and risky alcohol consumption (Li et al. 2012; Linardakis et al. 2015). MBRFs contribute to the increase in the prevalence of non-communicable diseases (NCDs), such as cardiovascular disease, type 2 diabetes, chronic obstructive pulmonary disease, arthritis and certain types of cancer (WHO 2014). In 2012, it was estimated that two-thirds of all deaths globally were attributed to NCDs, while 42% of deaths occurred in individuals <70 years of age (WHO 2014). The burden in mortality is greater when MBRFs appear in clusters, with the presence of 2+ factors associated with decreased life expectancy (Kvaavik et al. 2010).

The prevalence and definition of the clustering of behavioral risk factors (BRFs) appear to vary in different social or age groups and populations. For example, prevalence of the combination of five BRFs (cluster of 3+ factors) was 24.9% in a representative sample of the Chinese population aged 15-69 years (Li et al. 2012), whereas prevalence of having 2+ factors was 58% in Americans aged 18+ years (Fine et al. 2004), 53.4% in Europeans aged 50+ (Linardakis et al. 2015) and 39.0% in Canadians aged 12+ (Klein-Geltink et al. 2006). In these populations, the prevalence of MBRFs was most apparent in men and those who lived alone or had low educational status. In younger ages (adolescents and young adults), the prevalence of having 2+ factors has been reported to range from 6.0% to 65.0%, while the most commonly reported BRF appears to be physical inactivity (Alamian and Paradis 2009; Klein-Geltink et al. 2006; Kritsotakis et al. 2016; Smpokos et al. 2014).

The transition from adolescence to young adulthood (i.e. from high school to university) is a crucial period characterized by higher levels of independence and the acquisition of unfavorable lifestyle habits (Kritsotakis et al. 2016; Smpokos et al. 2014). A number of studies have reported that prevalence of smoking increases, and consumption of fruits and vegetables decreases during individuals’ undergraduate studies (Alexopoulos et al. 2010; Lionis et al. 2006; Steptoe et al. 2002). Moreover, the prevalence of having 2+ BRFs appears to reach 84.0% in medical students, the equivalent of 2.4 factors per student (Keller et al. 2008). Medical students, in particular, are a population of distinct interest, considering their future responsibility for population health care and public health. In addition, some studies have suggested that the adoption of unhealthy behaviors is inversely associated with medical students' academic performance (Gedefaw et al. 2015; Raupach et al. 2015). The evidence base is limited, however, and to our knowledge, no study to date has examined the association between BRF clustering and academic performance. This is important before regular health assessment programs in medical students are put in place and appropriate preventive strategies to decrease the prevalence of MBRFs in this population are developed (Lionis et al. 2006).

The aim of this observational study was therefore to assess the prevalence of MBRFs among undergraduate medical students in Crete, Greece, and evaluate their associations with academic performance.

Methods

Participants

For the purpose of the current study, a subset of 1,447 medical students (78.1%) (704 men/743 women), aged 19.5-40.0yrs, living in Crete (Greece), were selected from a total sample of 1,852 students (**figure 1**). Participants were recruited from all students (n=1,948) who were registered in the second or third year of studies in the Medical School of the University of Crete, during the period 1989-2011 (i.e. students who were admitted during the academic years 1986/87 through to 2010/11). Every academic year, these students participated in a Health and Nutrition survey, conducted as part of the requirements for the mandatory Clinical Nutrition course, ran by the Preventive Medicine and Nutrition Clinic of the Medical School (Bertsias et al. 2003; Kafatos 2009; Mammas et al. 2003). Detailed information on the study design (recruitment procedures, response rates, ethical issues etc) is provided in earlier reports (Bertsias et al. 2003; Kafatos 2009; Mammas et al. 2003).

Data collection

During every academic year between 1989-2011, the aforementioned medical students underwent a clinical examination, where information on demographic characteristics, physical health status and lifestyle behaviors was collected and anthropometric, blood pressure and biochemical measurements were provided. Details of the methods used to collect data are described elsewhere (Bertsias et al. 2003; Kafatos 2009; Mammas et al. 2003). The same questionnaires and assessment methods were applied during the research period (with additional questions or clinical examinations incorporated as newer methods became available, as appropriate), while detailed standard operating procedures ensured standardization in data collection. The MBRFs assessed (described in detail in the next section) were smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits/vegetables. Academic performance data were also collected up to the academic year 2016/2017.

Multiple Behavioral Risk Factors (MBRFs)

Five MBRFs were assessed, which related to daily habits and health behaviors, including smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits/vegetables (Linardakis et al. 2015; Smpokos et al. 2014). Smokers were classified as those who stated smoking more than one cigarette per day for at least the last three consecutive months (Mammas et al. 2003). High body weight was determined based on measurements of body weight and height, as having body mass index (BMI) $\geq$25.0 kg/m^2 (i.e. being overweight or obese). Weight was measured on calibrated digital scales (Seca 861) to the nearest 0.1 kg and height was measured to the nearest 0.5 cm with a wall-mounted stadiometer (Seca 225) (Bertsias et al. 2003). Physical inactivity was defined, using a weighted weekday-weekend physical activity questionnaire, as the lack of daily engagement in moderate-to-vigorous activities during the research period (i.e. having less than 30 minutes/day of these activities) (Vardavas et al. 2009). Risky alcohol consumption was defined as the consumption of $\geq$12 servings/week of alcoholic beverages for at least three consecutive months or consuming $\geq$176 g/week of pure alcohol (Mammas et al. 2003). Low consumption of fruits/vegetables was determined by a 24-hour dietary recall and defined as <400 g/day (Bertsias et al. 2005).

To estimate the clustering of MBRFs, each factor was coded separately into a binary variable (0: absence, 1: presence). The prevalence of clustering was then estimated by adding the binary variables, resulting in a clustering score ranging from 0-5. ‘Multiple clustering of 3+ factors’ was considered to depict higher risk for chronic diseases (Linardakis et al. 2015; Smpokos et al. 2014).

Academic performance and other characteristics

Academic performance was based on the grades received in the mandatory Clinical Nutrition course (assessing clinical nutrition knowledge, n=1,447) and Medical degree (assessing overall undergraduate performance, n=1,358). The Clinical Nutrition course grades correspond to the average of a written exam taken at the end of the semester (or a re-sit in September of each academic year), and a group project involving the assessment and evaluation of patient case studies. Grades received in a course range from 0 to 10, with 5 representing the pass mark. For the purposes of the current study, the Clinical Nutrition grades included those of 37 students (2.6%) who had sat the exams until the academic year 2016/2017 and failed (their grades were <5). The attempts to pass the Clinical Nutrition course were also recorded. For the overall Medical degree, the grades of all students who had graduated by the end of academic year 2016/2017 (30^{th} September, 2017) were recorded (89 students did not graduate because of withdrawals, registration to other schools or inability to fulfill university graduation requirements). Medical degree grades were classified according to the Greek Higher Education system as 'good' (pass, 5.00-6.49), 'very good' (merit, 6.50-8.49) and 'excellent' (distinction, 8.50-10.0).

Demographic characteristics assessed included age, gender and area of permanent residence. Academic information included collecting data on study periods (based on the initial database of 989 students in 1989-2001 (Bertsias et al. 2003; Mammas et al. 2003) and the a posteriori renewal of the database with data from 2002-2011). Information on which academic semester students were registered on was also collected, due to changes in the curriculum during the research period, and classified into 5^{th}, 6^{th}, or $\geq 7^{th}$.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (IBM-SPSS, 24, 2011, Chicago, Illinois, USA). Prevalence of individual and BRF clusters, with 95% confidence intervals (95% CIs) was estimated. In addition to the observed (O) prevalence, the expected (E) prevalence of individual and BRF clusters was assessed in order to estimate O/E ratios and provide the most frequent combinations of the five BRFs (Linardakis et al. 2014; Schuit et al. 2002). For example, six students were found as risky alcohol drinkers and physically inactive, and for this category of combinations the observed prevalence of non smoking was 100-25.8%=74.2% (or 0.742), of normal weight 100-30.7%=69.3% (or 0.693), of alcohol consumption 5.9% (or 0.059), of physical inactivity 12.7% (or 0.127), of regular consumption of fruits and vegetables 100-67.2%=32.8% (or 0.328), and the expected prevalence for the combination of risky alcohol consumption and physical inactivity would be 0.742x0.693x0.059x0.127x0.328=0.13 or 13% (table 4). The Chi-square test was used to examine differences in BRF prevalence according to gender and Medical degree grade classification. Analysis of covariance, with gender, age, semester and study periods (due to potential heterogeneity caused by the long time period of the study) (Bertsias et al. 2003; Curran and Hussong 2009; Miech et al. 2017) as covariates, was used to examine differences and polynomial trends in BRF clustering (‘0’, ‘1’, ‘2’, ‘3+’ factors) according to academic performance (grades received in the Clinical Nutrition course and overall Medical degree). The models’ heterogeneity was tested using Levene’s test.

Results

Table 1 presents the descriptive characteristics of participants. Mean age of participants was 21.8yrs (±2.2), 13.1% were aged ≥24.0yrs and 48.7% were men. The majority of participants (90.8%) came from urban or suburban areas and 58.5% attended the Clinical Nutrition course in the ≥7th semester.

⇨ Table 1

Prevalence of BRFs in the total sample was 25.8% for smoking, 30.7% for high body weight, 5.9% for risky alcohol consumption, 12.7% for physical inactivity and 67.2% for low consumption of fruits/vegetables (**table 2**). Prevalence of high body weight (43.9% vs. 18.2%, p < 0.001) and risky drinkers (9.2% vs. 2.8%, p <0.001) was higher in men, compared to women. With regards to clustering of BRFs (**table 3**), only 15.8% (95% CI=14.0-17.7) of participants had no risk factors, while 12.3% (95% CI=10.6-13.9) had 3+ factors, with men having almost double the prevalence of this multiple clustering than women (16.5% vs. 8.4%, p < 0.001). The combination of risky alcohol consumption and physical inactivity had the greatest degree of clustering, as the observed prevalence was 238% higher than the expected one (O/E=3.28) (**table 4**).

⇨ Tables 2, 3, 4

The mean levels of academic performance of participants (as indicated by the grades received) according to the clustering of MBRFs are illustrated in **figure 2**. Participants who had none, compared to 3+, MBRFs had higher mean grades in the Clinical Nutrition course (6.34 vs. 5.94, p = 0.027, p-trend = 0.003) and overall degree (7.39 vs. 7.22, p = 0.021, p-trend = 0.002).

⇨ Fig 2

With regards to individual BRFs, smokers achieved lower mean grades in the Clinical Nutrition course (5.99 vs. 6.20, p = 0.007) and overall degree (7.21 vs. 7.35, p < 0.001), compared to non-smokers. In addition, participants who had high body weight, compared to those with normal weight (7.25 vs. 7.34, p = 0.012) and participants who were physically active, compared to those who were inactive (7.30 vs. 7.41, p = 0.008), achieved lower mean grades in their overall degree. Finally, 4.1% (n=56) of the students graduated with a ‘good’ degree classification, 92.6% (n=1,257) with ‘very good’ and 3.3% (n=45) with ‘excellent’. The mean number of attempts in succeeding in the Clinical Nutrition course exam was 1.59 (±1.11), while 66.9% of participants passed on the first attempt. As the number of MBRFs increased (from ‘none’ to ‘1’, ‘2’ and ‘3+’ factors), the proportion of graduates receiving a distinction also decreased (6.1%, 3.3%, 3.3% and 0.0%, respectively, *p*-trend=0.001).

Discussion

This observational study assessed the prevalence of MBRFs and their association with academic performance in a sample of Greek undergraduate medical students. Overall, high prevalence of individual MBRFs was observed, with low consumption of fruits/vegetables being the most prevalent BRF. The findings also suggested that academic performance decreased with the increase in MBRF clustering.

Prevalence of unhealthy behaviors was apparent in this sample of students, which is in agreement with earlier studies in other student or population groups (Anderson and Good 2017; Burrows et al. 2017; Chourdakis et al. 2010; Kritsotakis et al. 2016; Mekonen et al. 2017; Steptoe et al. 2002; Suraya et al. 2017). The behavioral profile of undergraduate medical students, already adopted in their teenage years and carried through to adulthood upon University entry, constitutes a particularly interesting trait of this population group. This is because this profile stems not only from all the lifestyle choices medical students will make, but also from the healthy behaviors they will adopt due to their clinical, person-centered training and which they might inflict upon their patients in future consultations (Gedefaw et al. 2015; Kafatos 2009; Raupach et al. 2015). A common feature of earlier studies investigating MBRFs for non-communicable diseases is the focus on combined (clustered) BRF prevalence, and thereafter its relationship with overall morbidity and mortality (Kvaavik et al. 2010; Linardakis et al. 2015). It appears, also, that a variety of multiple behaviors during medical students’ undergraduate studies should be considered when attempting to assess their health-related risk (Kritsotakis et al. 2016). The role of clinicians’ lifestyle choices in screening and counseling of their patients is evident in other studies, such as the Women Physician’s Health Study of approximately 4,500 general practitioners (Frank et al. 2000), particularly regarding lifestyle behaviours such as smoking and alcohol consumption. In this study, general practitioners who themselves were attempting to improve their lifestyle behaviours were more likely to discuss these behavioral risk factors with their patients. It was also suggested that practicing healthy lifestyle behaviours themselves offered general practitioners a means of continuous professional development with regards to prevention-related counseling and screening, which would be invaluable for practitioners' training in preventing MBRFs (Frank et al. 2000).

One of the main findings of the present study was the high prevalence of both individual BRFs and their clusters. The most prevalent BRF was the low consumption of fruit/vegetables, as 67.2% of participants consumed <400 g/day. Earlier studies among Greek University students have reported conflicting findings for this BRF. In 1,058 first-year students of Technological Schools in Crete in 2012, only 9.4% reported consuming fruits/vegetables >1 time/day (Kritsotakis et al. 2016), whereas regular consumption of fruits/vegetables was observed in a sample of 390 medical students in Northern Greece in 2009 (Chourdakis et al. 2010). An earlier longitudinal study of approximately 20,000 University students in 13 European countries also found that daily fruit consumption decreased by 15% between 1990 and 2000 (Steptoe et al. 2002). Overall, these findings highlight the importance of intervention strategies to promote the recommended intake of fruits and vegetables among University students. Although the current study did not suggest that levels of academic performance differed according to presence or not of low intake of fruits and vegetables, small-to-moderate consumption of fruit (≥2 servings/day) has previously been positively associated with academic performance (Odds Ratio=1.09; 95% CI=1.05-1.13) (Burrows et al. 2017). Fruits and vegetables, however, are only one dietary component among others (including regular breakfast consumption, lower consumption of junk foods and the intake of essential micronutrients, such as iron and folate), which have been associated with higher levels of academic performance in University students (Anderson and Good 2017; Burrows et al. 2017). Ideally, future studies in this sample of medical students should explore a wider range of nutritional factors to establish associations with this outcome.

Those participants who were smokers and those with high body weight had lower levels of academic performance compared to non-smokers and those with normal BMI, respectively. The use of various substances (e.g. current smoking, chewing khat, drinking alcohol on a daily basis) has previously been inversely associated with academic performance (Mekonen et al. 2017). University students who are smokers have been found to face health complications that might affect their engagement with, or performance in their studies, such as higher rates of respiratory infections or bacterial meningitis, exacerbated by living in dorms (Lussier 2015). The association between high body weight and low academic performance has also been suggested by earlier studies among Saudi Arabian (Suraya et al. 2017) and American (Anderson and Good 2017) University students. Similar to the role of fruits/vegetables in academic performance, individuals with increased body weight might struggle academically because of other dietary habits, such as regular fast food consumption or high intakes of saturated fat and added sugars, which in turn have been linked to cognitive decline (Anderson and Good 2017). In addition, the role of physical activity in enhanced academic performance has widely been documented (Al-Drees et al. 2016; Lizandra et al. 2016). In contrast, participants who engaged in moderate-to-vigorous physical activity in the current study achieved a lower mean grade in their overall degree, compared to those who were inactive. The grade of the degree, however, is determined by the overall academic performance over the five years of undergraduate medical studies, whereas physical activity in the current study, in addition to the other BRFs of interest, was assessed over a short period of time (before or during the Clinical Nutrition course), at the beginning or in the middle of participants' undergraduate studies. Particularly for participants recruited during their 7th semester of studies, the potential effect of the level of study commitment and difficulty of coursework should be taken into consideration when interpreting these findings, as study requirements might interfere with, and limit participation in physical activity or organized sports (Lizandra et al. 2016).

With regards to the prevalence of BRF clustering, it was observed that approximately 12% of participants had 3+ MBRFs, which is in contrast to the higher prevalence (53%) reported among German University students (Keller et al. 2008). In addition, men had almost twice the prevalence of BRF clustering, compared to women. One of the most important findings of the current study, however, was that levels of academic performance, demonstrated by the grades achieved in both the Clinical Nutrition course and the overall Medical degree, decreased as clustering of BRFs increased. To our knowledge, this is the first study to investigate the association between BRF clustering and academic performance, which hinders comparisons with other studies. However, given the plausibility of this association, this finding highlights the need for preventive measures to reduce the prevalence of MBRFs in this sample of medical students, mainly via their undergraduate education (Kafatos 2009). This could involve interventions through the medical curriculum, with expansion in the scope of educational materials, but also environmental interventions to encourage the adoption of healthier lifestyles and/or discourage the adoption or maintenance of risky behaviors, which, in turn, might positively impact on these medical students' future patients (Gedefaw et al. 2015; Kafatos 2009; Raupach et al. 2015).

With regards to specific combinations of BRFs, the combination of risky alcohol consumption and physical inactivity had the greatest degree of clustering in the current study and was 238% higher than expected (O/E=3.28). This is in contrast to earlier studies, which have reported low clustering of these BRFs among Canadian children and adolescents aged 10-17yrs (boys=0.70; girls=0.43) (Alamian and Paradis 2009) and Dutch adults aged 20-59yrs (men=0.4; women=0.5) (Schuit et al. 2002), a difference that reveals the potential distinctiveness of medical students as a population sub-group susceptible in adopting MBRFs and in need of intervention to reduce their clustering.

The lack of a common definition of MBRFs, particularly regarding their number and cut-off points (Linardakis et al. 2015), is an important limitation of this study. In addition, data have been collected over a period of 24 years, which might conceal secular trends in BRF prevalence and/or academic performance. However, adjusting analyses for study period (1989-2001 and 2002-2011) should have helped overcome this limitation (Bertsias et al. 2003; Curran and Hussong 2009; Miech et al. 2017). Further, factors such as participants' medical history, their overall dietary assessment and biochemical profiles might have mediated the relationship between MBRFs and academic performance, but such investigation was beyond the scope of the current report. Finally, MBRF assessment was conducted at a given point in time, and was retrospectively associated with the academic performance achieved in the Clinical Nutrition course and throughout participants' studies. These measures, however, were considered to be the best available objective academic performance indicators, compared to e.g. self-reported academic achievement.

Conclusion

Overall, high prevalence of MBRFs was observed in this sample of medical students, while prevalence of MBRF clustering was prospectively inversely associated with academic performance. As medical students will be responsible for patients of their own, to whom they will act as role models (Gedefaw et al. 2015; Kafatos 2009; Labadarios and Kafatos 1991; Raupach et al. 2015), preventive strategies are needed to improve the lifestyle and behavioral risk factors in this population group during their undergraduate studies.

Acknowledgements

The authors would like to thank all students who participated in this study. We also thank to Mrs. Eleutheria Tzorakis, Olympia Ksilouris and Sofia Flouris for their valuable assistance in data preparation.

Funding

None declared

Disclosure of potential conflicts of interest

The authors declare that they have no conflict of interest.

Compliance with Ethical Standards

Research involving Human Participants

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of the University Hospital of Heraklion, Crete, Greece and with 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

References

Al-Drees A, Abdulghani H, Irshad M, Baqays AA, Al-Zhrani AA, Alshammari SA et al. (2016) Physical activity and academic achievement among the medical students: A cross-sectional study Med Teach 38:S66-S72 doi:10.3109/0142159x.2016.1142516

Alamian A, Paradis G (2009) Clustering of chronic disease behavioral risk factors in Canadian children and adolescents Prev Med 48:493-499 doi:10.1016/j.ypmed.2009.02.015S0091-7435(09)00113-3

Alexopoulos E, Jelastopulu E, Aronis K, Dougenis D (2010) Cigarette smoking among university students in Greece: a comparison between medical and other students Environ Health Prev Med 15:115-120 doi:10.1007/s12199-009-0110-0

Anderson A, Good D (2017) Increased body weight affects academic performance in university students Prev Med Rep 5:220-223 doi:10.1016/j.pmedr.2016.12.020S2211-3355(16)30172-3

Bertsias G, Linardakis M, Mammas I, Kafatos A (2005) Fruit and vegetables consumption in relation to health and diet of medical students in Crete, Greece Int J Vitam Nutr Res 75:107-117 doi:10.1024/0300-9831.75.2.107

Bertsias G, Mammas I, Linardakis M, Kafatos A (2003) Overweight and obesity in relation to cardiovascular disease risk factors among medical students in Crete, Greece BMC Public Health 3:3 doi:10.1186/1471-2458-3-3

Burrows LT, Whatnall CM, Patterson JA, Hutchesson JM (2017) Associations between Dietary Intake and Academic Achievement in College Students: A Systematic Review Healthcare 5 doi:10.3390/healthcare5040060

Chourdakis M, Tzellos T, Papazisis G, Toulis K, Kouvelas D (2010) Eating habits, health attitudes and obesity indices among medical students in northern Greece Appetite 55:722-725 doi:10.1016/j.appet.2010.08.013

Curran P, Hussong A (2009) Integrative data analysis: the simultaneous analysis of multiple data sets Psychol Methods 14:81-100 doi:10.1037/a0015914

Fine L, Philogene G, Gramling R, Coups E, Sinha S (2004) Prevalence of multiple chronic disease risk factors. 2001 National Health Interview Survey Am J Prev Med 27:18-24 doi:10.1016/j.amepre.2004.04.017S0749379704000972

Frank E, Rothenberg R, Lewis C, Belodoff B (2000) Correlates of physicians' prevention-related practices. Findings from the Women Physicians' Health Study. Arch Fam Med 9:359-367

Gedefaw A, Tilahun B, Asefa A (2015) Predictors of self-reported academic performance among undergraduate medical students of Hawassa University, Ethiopia Adv Med Educ Pract 6:305-315 doi:10.2147/AMEP.S78604amep-6-305

Kafatos A (2009) Is Clinical Nutrition Teaching Needed in Medical Schools? Ann Nutr Metab 54:129-130 doi:10.1159/000210372

Keller S, Maddock J, Hannover W, Thyrian J, Basler H (2008) Multiple health risk behaviors in German first year university students Prev Med 46:189-195 doi:10.1016/j.ypmed.2007.09.008

Klein-Geltink J, Choi B, Fry R (2006) Multiple exposures to smoking, alcohol, physical inactivity and overweight: Prevalences according to the Canadian Community Health Survey Cycle 1.1 Chronic Dis Can 27:25-33

Kritsotakis G, Psarrou M, Vassilaki M, Androulaki Z, Philalithis A (2016) Gender differences in the prevalence and clustering of multiple health risk behaviours in young adults J Adv Nurs 72:2098-2113 doi:10.1111/jan.12981

Kvaavik E, Batty GD, Ursin G, Huxley R, Gale CR (2010) Influence of individual and combined health behaviors on total and cause-specific mortality in men and women: the United Kingdom health and lifestyle survey Arch Intern Med 170:711-718 doi:170/8/71110.1001/archinternmed.2010.76

Labadarios D, Kafatos A (1991) Teaching of clinical nutrition at the University of Crete, School of Medicine, Greece Nutrition 7:61-63

Li Y, Zhang M, Jiang Y, Wu F (2012) Co-variations and clustering of chronic disease behavioral risk factors in China: China Chronic Disease and Risk Factor Surveillance, 2007 PLoS One 7:e33881 doi:10.1371/journal.pone.0033881

Linardakis M, Papadaki A, Smpokos E, Komninos Y, Philalithis A (2014) Multiple behavioral risk factors for chronic diseases in adults aged 50+: regional differences across eleven European countries Journal of Public Health 22:101-109 doi:10.1007/s10389-013-0597-0

Linardakis M, Papadaki A, Smpokos E, Micheli K, Vozikaki M, Philalithis A (2015) Association of Behavioral Risk Factors for Chronic Diseases With Physical and Mental Health in European Adults Aged 50 Years or Older, 2004-2005 Prev Chronic Dis 12:E149 doi:10.5888/pcd12.150134

Lionis C, Thireos E, Antonopoulou M, Rovithis E, Philalithis A, Trell E (2006) Assessing university students' health needs: lessons learnt from Crete, Greece Eur J Public Health 16:112-112 doi:10.1093/eurpub/cki225

Lizandra J, Devís-Devís J, Pérez-Gimeno E, Valencia-Peris A, Peiró-Velert C (2016) Does Sedentary Behavior Predict Academic Performance in Adolescents or the Other Way Round? A Longitudinal Path Analysis PLoS One 11:e0153272 doi:10.1371/journal.pone.0153272

Lussier A (2015) How Tobacco Use Could Hinder Your Academic Performance as a College Student? University of New Hampshire https://www.unh.edu/healthyunh/blog/tobacco/2015/10/how-does-tobacco-use-impact-your-academic-performance Accessed date: 24 July 2018;.

Mammas I, Bertsias G, Linardakis M, Tzanakis N, Labadarios D, Kafatos A (2003) Cigarette smoking, alcohol consumption, and serum lipid profile among medical students in Greece Eur J Public Health 13:278-282 doi:10.1093/eurpub/13.3.278

Mekonen T, Fekadu W, Mekonnen TC, Workie SB (2017) Substance Use as a Strong Predictor of Poor Academic Achievement among University Students Psychiatry J 2017:9 doi:10.1155/2017/7517450

Miech R, Patrick M, O'Malley P, Johnston L (2017) The Influence of College Attendance on Risk for Marijuana Initiation in the United States: 1977 to 2015 Am J Public Health 107:996-1002 doi:10.2105/AJPH.2017.303745

Raupach T, Al-Harbi G, McNeill A, Bobak A, McEwen A (2015) Smoking cessation education and training in U.K. medical schools: a national survey Nicotine Tob Res 17:372-375 doi:10.1093/ntr/ntu199

Schuit A, van Loon A, Tijhuis M, Ocke M (2002) Clustering of lifestyle risk factors in a general adult population Prev Med 35:219-224 doi:S0091743502910649

Smpokos E, Linardakis M, Papadaki A, Sarri K, Kafatos A (2014) Clustering of chronic disease behavioral risk factors among adolescents in Crete (Greece): associations with biological factors and cardiorespiratory fitness levels J Public Health 22:433-442 doi:10.1007/s10389-014-0629-4

Steptoe A, Wardle J, Cui W, Bellisle F, Zotti A, Baranyai R et al. (2002) Trends in smoking, diet, physical exercise, and attitudes toward health in European university students from 13 countries, 1990-2000 Prev Med 35:97-104 doi:S0091743502910480

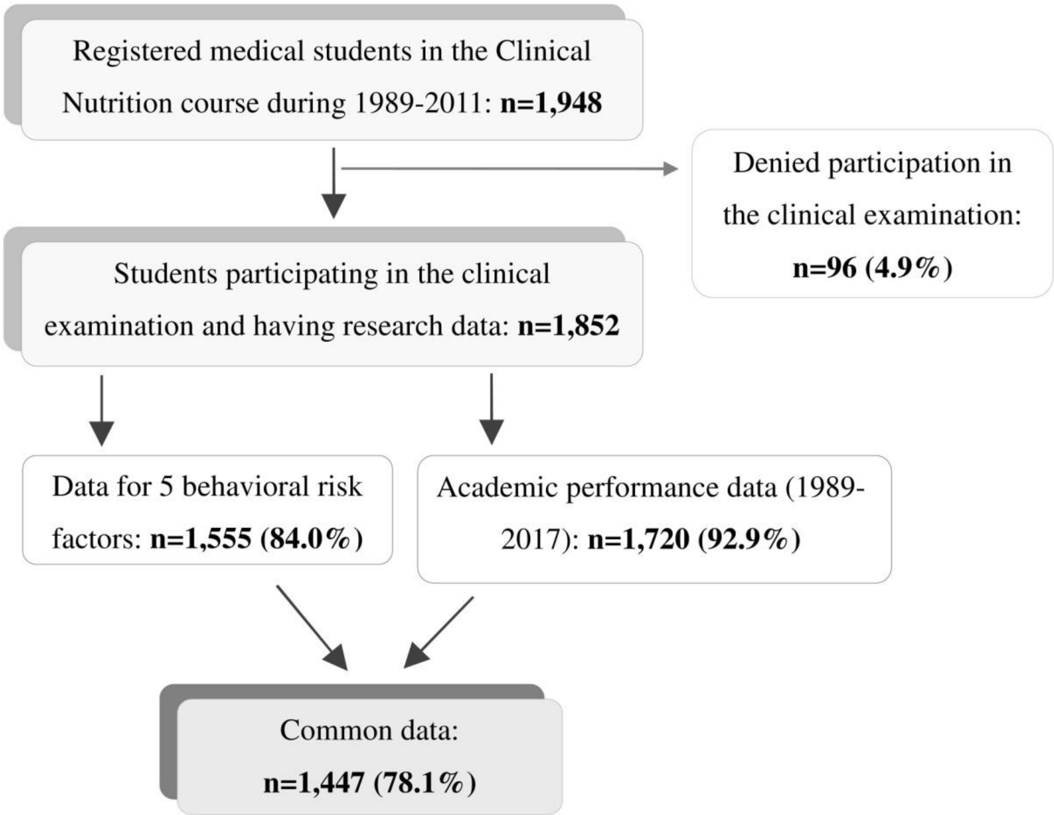
Suraya F, Meo S, Almubarak Z, Alqaseem Y (2017) Effect of obesity on academic grades among Saudi female medical students at College of Medicine, King Saud University: Pilot study J Pak Med Assoc 67:1266-1269 doi:8324

Vardavas C, Linardakis M, Hatzis C, Saris W, Kafatos A (2009) Prevalence of obesity and physical inactivity among farmers from Crete (Greece), four decades after the seven countries study Nutr Metab Cardiovasc Dis 19:156-162 doi:10.1016/j.numecd.2008.10.008

WHO (2014) Global Status Report on Noncommunicable Diseases. “Attaining the nine global noncommunicable diseases targets; a shared responsibility”. Geneva

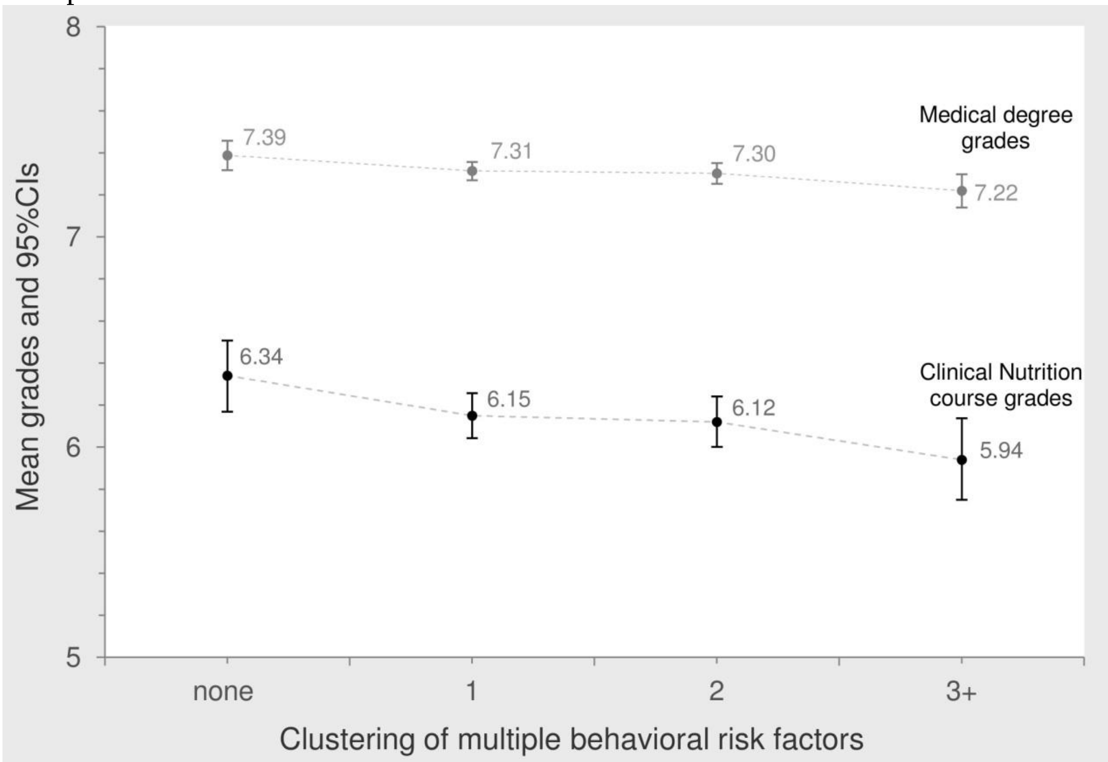
Figure legends

Figure 1. Flowchart of participants in research study.



Footnote to Figure 1:
The clinical examination involved the collection of data on demographic characteristics, physical health status and lifestyle behaviors, as well as anthropometric, blood pressure and biochemical measurements. The five behavioral risk factors assessed include smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits and vegetables.
Academic performance was based on the grades received in the mandatory Clinical Nutrition course (n=1,447) and the overall Medical degree (n=1,358).

Figure 2. Academic performance of medical students according to clustering of multiple behavioral risk factors.



Footnote to Figure 2:
95% CIs, 95% confidence intervals.
Academic performance was based on the grades received in the mandatory Clinical Nutrition course (n=1,447) and the overall Medical degree (n=1,358). The mean Medical degree grade was 7.31 (±0.53) and the mean Clinical Nutrition course grade was 6.15 (±1.34), including the grades of 37 students (2.6%) who sat the exams until the summer of 2017 but they failed (their grade was less than 5). The mean number of attempts to pass the exam was 1.59 (±1.11) (66.9% passed on the first attempt).
Differences according to clustering of behavioral risk factors were assessed using analysis of covariance (Medical degree grades: *p*-value=0.021 and polynomial *p*-trend=0.002; Clinical Nutrition course grades: *p*-value=0.027 and polynomial *p*-trend=0.003). Gender, age, semester (5^{th}, 6^{th}, $\geq 7^{th}$) and study period (1989-2001 and 2002-2011) were used as covariates. Heterogeneity was tested by Levene's test.

Table 1. Descriptive characteristics of 1,447 medical students in Crete (Greece), during 1989-2011.

		n	%
Gender	*men*	704	48.7
	women	743	51.3
Age, *years*	*<21.0*	500	34.6
	21.0-21.9	325	22.5
	22.0-22.9	306	21.1
	23.0-23.9	126	8.7
	≥24.0	190	13.1
	mean±stand. dev. (min, max)	21.8±2.2 (19.5, 40.0)	
Area of permanent residence [a]	*urban/suburban*	700	90.8
	rural	71	9.2
Study periods [b]	*1989-2001*	816	56.4
	2002-2011	631	43.6
Semesters [c]	*5th*	250	17.3
	6th	350	24.2
	≥7th	847	58.5

[a] Data were available for 771 students.
[b] Study periods were classified according to a previous publication (Bertsias et al. 2003).
[c] During the period 1989-2011, the Clinical Nutrition course changed and was taught in a different semester.

Table 2. Prevalence of five multiple behavioral risk factors among 1,447 medical students in Crete (Greece), according to gender.

Behavioral risk factors		**n**	**Percent,** %	**95% Confidence Intervals**
Smoking, *smokers*	*men*	192	27.3	24.0, 30.5
	women	182	24.5	21.4, 27.6
	total	374	25.8	23.4, 28.3
High body weight, *overweight/obese*	*men*	309	43.9	40.1, 47.6
	women	135	18.2	15.6, 20.9
	total	444	30.7	28.2, 33.1
Alcohol consumption, *risky drinkers*	*men*	65	9.2	7.1, 11.5
	women	21	2.8	1.6, 4.0
	total	86	5.9	4.7, 7.2
Physical inactivity	*men*	80	11.4	9.0, 13.9
	women	104	14.0	11.5, 16.5
	total	184	12.7	11.0, 14.6
Low consumption of fruits and vegetables	*men*	460	65.3	62.2, 69.1
	women	513	69.0	65.6, 72.4
	total	973	67.2	64.8, 69.8

Smokers were classified as those who stated smoking more than one cigarette per day for at least the last three consecutive months (Mammas et al. 2003). High body weight was determined as having body mass index (BMI) ≥25.0 kg/m^2 (i.e. being overweight or obese) (Bertsias et al. 2003). Physical inactivity was defined as the lack of daily engagement in moderate or vigorous activities during the research period (i.e. having less than 30 minutes/day of these activities (Vardavas et al. 2009). Risky alcohol consumption was defined as the consumption of ≥12 servings of alcoholic beverages per week for at least three consecutive months or consuming ≥176 g/week of pure alcohol, based on a 24-hour dietary recall (Mammas et al. 2003). Low consumption of fruits and vegetables was determined by a 24-hour recall and defined as <400 g/day (Bertsias et al. 2005).

Differences between genders were assessed using the chi-square test (strong evidence of a difference between genders was observed for high body weight and alcohol consumption, with p-values <0.001).

Table 3. Prevalence of clustering of behavioral risk factors among 1,447 medical students in Crete (Greece), according to gender.

Clustering of Multiple Behavioral risk factors	Total	Men	Women
	% (95% Confidence Intervals) [n]		
0 (none)	15.8 (14.0, 17.7) [229]	13.1 (10.5, 15.6) [92]	18.4 (15.8, 21.5) [137]
1	40.2 (37.6, 42.7) [582]	36.5 (33.0, 39.9) [257]	43.7 (40.0, 47.3) [325]
2	31.7 (29.3, 34.2) [458]	33.9 (30.6, 37.6) [239]	29.5 (26.3, 32.8) [219]
3+	12.3 (10.6, 13.9) [178]	16.5 (13.7, 19.5) [116]	8.4 (6.4, 10.3) [62]

Differences between genders were assessed using the chi-square test (strong evidence of a difference between genders was observed for clustering of 3+ behavioral risk factors, with p-values <0.001).

Table 4. Clustering of behavioral risk factors individually or in combination in 1,447 medical students in Crete (Greece).

Cluster of Risk factor	**Smoking,** *smokers*	**High body weight,** *Overweight & obese*	**Alcohol consumption,** *risky drinkers*	**Physical Inactivity**	**Low consumption of fruits and vegetables**	**n**	**O** (%)	**E** (%)	**O÷E**	**95% Confidence Intervals**	
none	-	-	-	-	-	229	15.83	13.86	1.14	0.63	1.83
1	+	-	-	-	-	41	2.83	4.82	0.59	0.09	1.66
1	-	+	-	-	-	94	6.50	6.14	1.06	0.41	2.24
1	-	-	+	-	-	7	0.48	0.87	0.55	0.01	4.24
1	-	-	-	+	-	30	2.07	2.02	1.03	0.12	3.58
1	-	-	-	-	+	410	28.33	28.39	1.00	0.66	1.43
2	+	+	-	-	-	30	2.07	2.13	0.97	0.11	3.39
2	+	-	+	-	-	11	0.76	0.30	2.52	0.01	15.58
2	+	-	-	+	-	6	0.41	0.70	0.59	0.01	5.27
2	+	-	-	-	+	142	9.81	9.87	0.99	0.45	1.80
2	-	+	+	-	-	7	0.48	0.38	1.26	0.01	9.71
2	-	+	-	+	-	10	0.69	0.89	0.77	0.01	5.25
2	-	+	-	-	+	177	12.23	12.58	0.97	0.49	1.67
2	-	-	+	+	-	6	0.41	0.13	3.28	0.01	28.38
2	-	-	+	-	+	14	0.97	1.78	0.54	0.01	2.62
2	-	-	-	+	+	60	4.15	4.13	1.00	0.26	2.48
3	+	+	+	-	-	3	0.21	0.13	1.55	0.01	28.37
3	+	+	-	+	-	4	0.28	0.31	0.89	0.01	11.90
3	+	+	-	-	+	68	4.70	4.37	1.07	0.31	2.50
3	+	-	+	+	-	1	0.07	0.04	1.57	-	-
3	+	-	+	-	+	17	1.17	0.62	1.90	0.04	8.99
3	+	-	-	+	+	24	1.66	1.44	1.16	0.07	4.46
3	-	+	+	+	-	0	-	0.06	-	-	-
3	-	+	+	-	+	3	0.21	0.79	0.26	0.01	4.66
3	-	+	-	+	+	24	1.66	1.83	0.91	0.05	3.50
3	-	-	+	+	+	0	-	0.26	-	-	-
4	+	+	+	+	-	0	-	0.02	-	-	-
4	+	+	+	-	+	10	0.69	0.27	2.52	0.01	17.31
4	+	+	-	+	+	12	0.83	0.64	1.30	0.01	7.30
4	+	-	+	+	+	5	0.35	0.09	3.84	-	-
4	-	+	+	+	+	2	0.14	0.11	1.21	0.01	33.53
5	+	+	+	+	+	0	-	0.04	-	-	-

+: presence of behavioral risk factor.
Observed (O) & Expected (E) combination frequencies of risk factors.